CHEMISTRY AND CHEMICAL ENGINEERING

Volume 2022 | Number 4 Article 19

March 2024

ESSENTIAL OILS INCORPORATION TECHNOLOGY TO IMPROVE SHELFLIFE AND STABILITY OF YOGHURT

Mohamed RIFKY
Eastern University, Sri Lanka, Chenkalady, Sri Lanka; Tashkent Chemical-Technological Institute, Tashkent, Uzbekistan, rifkyalm@esn.ac.lk

Kamar SERKAYEV
Tashkent Chemical-Technological Institute, Tashkent, Uzbekistan, serkayer@mail.ru

Murodjon SAMADIY
Yangiyer branch of Tashkent Chemical-Technological Institute, Yangiyer, Uzbekistan, samadiy@inbox.ru

Recommended Citation
RIFKY, Mohamed; SERKAYEV, Kamar; and SAMADIY, Murodjon (2024) "ESSENTIAL OILS INCORPORATION TECHNOLOGY TO IMPROVE SHELFLIFE AND STABILITY OF YOGHURT," *CHEMISTRY AND CHEMICAL ENGINEERING*: Vol. 2022: No. 4, Article 19.
DOI: 10.34920/cce202248
Available at: https://cce.researchcommons.org/journal/vol2022/iss4/19

ESSENTIAL OILS INCORPORATION TECHNOLOGY TO IMPROVE SHELFLIFE AND STABILITY OF YOGHURT

Mohamed RIFKY[1,2] (rifkyalm@esn.ac.lk), Kamar SERKAYEV[2] (serkayer@mail.ru), Murodjon SAMADIY[1] (samadiy@inbox.ru)
[1]Eastern University, Sri Lanka, Chenkalady, Sri Lanka
[2]Tashkent Chemical-Technological Institute, Tashkent, Uzbekistan
[3]Yangiyer branch of Tashkent Chemical-Technological Institute, Yangiyer, Uzbekistan

The purpose of this study is to develop a technology for incorporating essential oils (EOs) into yogurt. Various essential oils such as cinnamon oil, garlic oil, caraway oil and clove oil in yogurt are used as antimicrobial and stabilizing agents to increase shelf life and stability. Three hundred µl/kg of essential oil was added to the yogurt after pasteurization to prevent deterioration of functional properties when heated. To determine the antibacterial activity of the main bacterial pathogens, such as total aerobic count of bacteria, yeasts and molds, the total number of bacteria on plates (pour method), the total number of Escherichia coli (plate method) and molds were assessed. Texture analysis, solids content, pH and titratable acidity and texture, water holding capacity of the samples were analyzed and it was found that the solids and pH of the yogurts were only slightly affected, while the stability of the yogurt was slightly improved, and the texture of the sample with the addition of ether garlic oil was significantly higher than all, while the cinnamon essential oil sample showed the highest acceptability.

Garlic essential oil has been found to be the best essential oil to include in yogurt to reduce viable bacteria and mold. Cinnamon EO and clove EO added to the samples showed little inhibition, respectively. The highest overall acceptance was observed in the yogurt supplemented with cinnamon EO, and the best organoleptic properties were obtained in the yogurt supplemented with clove EO. The addition of cinnamon, garlic, cumin and clove essential oils can increase shelf life, organoleptic properties and texture, while the texture of yogurt is greatly improved.

.

Keywords: Essential oil, Cinnamon Oil, Clove Oil, Cumin oil, Garlic oil

ТЕХНОЛОГИЯ ВНЕСЕНИЯ ЭФИРНЫХ МАСЕЛ ДЛЯ УЛУЧШЕНИЯ СРОКА ХРАНЕНИЯ И СТАБИЛЬНОСТИ ЙОГУРТА

Мохамед РИФКИЙ[1,2] (rifkyalm@esn.ac.lk), Камар СЕРКАЕВ[2] (serkayer@mail.ru), Муроджон САМАДИЙ[3] (samadiy@inbox.ru)
[1]Университет Эастерн, Шри Ланка, Ченкаладей, Шри Ланка
[2]Ташкентский химико-технологический институт, Ташкент, Узбекистан
[3]Янгиерский филиал Ташкентского химико-технологического института, Янгиер, Узбекистан

Целью данного исследования является разработка технологии включения эфирных масел (ЭМ) в йогурт. Используется различные эфирные масла, такие как коричное масло, чесночное масло, тминное масло и гвоздичное масло в йогурте, в качестве антимикробных и стабилизирующих агентов для увеличения срока годности и стабильности. Тристо мкл/кг эфирного масла вводили в йогурт после пастеризации, чтобы предотвратить снижение функциональных свойств при нагревании. Для определения антибактериальной активности основных переносимых бактерий, таких как общее аэробное количество бактерий, дрожжей и плесени, оценивали общее количество бактерий на чашках (метод насыпания), общее количество кишечных палочек (метод на чашках) и плесени. Анализ текстуры, содержание твердых веществ, pH и титруемая кислотность и текстура, водоудерживающая способность образцов были проанализированы и было обнаружено, что сухие вещества и pH йогуртов были затронуты лишь незначительно, в то время как стабильность йогурта была немного улучшена, а текстура образца с добавлением эфирного масла чеснока была значительно выше чем все, в то время как образец с добавлением эфирного масла корицы показал самую высокую приемлемость.

Было обнаружено, что лучшими эфирными маслами для включения в йогурт для снижения количества жизнеспособных бактерий и плесени является эфирное масло чеснока. ЭМ корицы и эфирное масло гвоздики, добавленные в пробы, показали небольшое ингибирование, соответственно. Наибольшее общее признание наблюдалось в йогурте с добавлением ЭМ корицы, а наилучшие органолептические свойства были получены в йогурте с добавлением ЭМ гвоздики. Добавление эфирных масел корицы, чеснока, тмина и гвоздики может увеличить срок годности, органолептические свойства и текстуру, в то время как текстура йогурта значительно улучшается.

Ключевые слова: эфирное масло, масло корицы, масло гвоздики, масло тмина, масло чеснока

YOGURTNING YAROQLILIK MUDDATINI VA BARQARORLIGINI OSHIRISH UCHUN EFIR MOYLARINI KIRITISH TEXNOLOGIYASI

Mohamed RIFKY[1,2] (rifkyalm@esn.ac.lk), Qamar SERKAYEV[2] (serkayer@mail.ru), Murodjon SAMADIY[3] (samadiy@inbox.ru)
[1]Eastern Universiteti, Shri Lanka, Chenkalady, Shri Lanka
[2]Toshkent kimyo-texnologiya instituti, Toshkent, O'zbekiston
[3]Toshkent kimyo-texnologiya instituti Yangiyer filiali,Yangiyer, O'zbekiston

Ushbu tadqiqotning maqsadi yogurtga efir moylarini (EM) kiritish texnologiyasini ishlab chiqishdir. Yogurtdagi dolchin moyi, sarimsoq moyi, zira moyi va chinnigullar moyi kabi turli xil efir moylari saqlash muddati va barqarorligini oshirish uchun mikroblarga qarshi va barqarorlashtiruvchi vositalar sifatida ishlatiladi. Pasterizatsiyadan so'ng yogurtga uch yuz µl\kgefir moyi qo'shildi, bu isitishdafunktsional xususiyatlarni pasayishini oldini olish maqsadida bajarildi. Bakteriyalar, xamirturushlar va mog'orlarning umumiy aerob soni kabi asosiy bakterial patogenlarning antibakterial faolligini aniqlash uchun plastinkalardagi bakteriyalarning umumiy soni (sochish usuli), ichak tayoqchasi (plastinka usuli) va mog'orlarning umumiy soni aniqlandi. Tekstura tahlili, qattiq moddalar tarkibi, pH va titrlanadigan kislotalilik va tekstura, namunalarning suvni ushlab turish qobiliyati tahlil qilindi va yogurtlarning quruq moddalari va pH darajasiga ozgina ta'sir qilgani, yogurtning barqarorligi esa biroz yaxshilanganligi aniqlandi, efir sarimsoq yog'i qo'shilgan namunaning teksturasi hammadan sezilarli darajada yuqori edi, dolchin efir moyi namunasi esa eng yuqori maqbullikni ko'rsatdi.

Sarimsoq efir moyi yashovchan bakteriyalar va mog'orlarni kamaytirish uchun yogurt tarkibiga qo'shiladigan eng yaxshi efir moyi ekanligi aniqlandi. Namunalarga qo'shilgan doljin EM va chinnigullar efir moyi mos ravishda ozgina inhibisyon xususiyatni ko'rsatdi. Eng yuqori umumiy qabul qilish dolchin EM bilan to'ldirilgan yogurtda kuzatilgan va eng yaxshi organoleptik xususiyatlar chinnigullar EM bilan to'ldirilgan yogurtda olingan. Dolchin, sarimsoq, zira va chinnigullar efir moylari qo'shilishi organoleptik xususiyatlarini va struktura mutadilligini oshirishi mumkin, yogurtning tarkibi esa sezilarli darajada yaxshilanadi.

Kalit so'zlar: efir moyi, dolchin moyi, chinnigullar moyi, zira moyi, sarimsoq moyi

DOI: 10.34920/cce202248

Introduction

Yoghurt is a popular fermented milk product and carries a health benefit due to its probiotic cultures. Milk and starter cultures activity is enough to produce a yogurt product in traditional level. This product contains high amount of fat and protein. These compounds play an important role in formation of its sensory properties. During produc-

tion of natural yoghurt, the use of optimal method for standardize the fat level is fundamental for quality of final products. Weak body, syneresis and poor taste and flavor impair acceptability of yoghurt. However, in practice in large industries, yogurt milks total solids content needs to be adjusted to produce better products without syneresis. Standardization technique is used to balance the fat level in the milk to get required level of fat for yoghurt production [1].

Modern day food producers are constantly seeking to understand essential oils in order to explain why they exhibit the medicinal, functional effects that each of them is known for. For instance, chemical analysis of essential oil reveals that its main active component is important for their functionality. Some essential oils are promising alternatives to chemical food additives as preservatives, flavorings, and antioxidants [2, 3]. Yogurts are fortified with some locally available natural functional ingredients to enhance its functionality including probiotic bacteria [4], also prebiotic bacterial additives [5] plant originated derived phenolics compounds [6] and some dietary fibers [7]. However, more scientific research studies concerning their compositions and applications are required. The antimicrobial effects of essential oils in food matrices need to be extensively addressed; such researches will assist the development of new preservatives from essential oils. Furthermore, studies of the shelf life and stability of essential oils during food processing are of particular interest. Studies of interactions of spice (mustard, cumin, pepper, garlic) essential oil food components with different food matrices during processing and storage under diverse environmental conditions are of valuable requirement. Cumin seeds are utilized worldwide for edible and medicinal applications [8, 9, 10]. Also, it is added to some food products such as paste, pastry, cheese, pickles and bakery products for flavoring [11, 12].

The major classical uses of EOs extracted from different spices are natural flavoring materials, which have great commercial importance. Worldwide demand for essential oils extracted from spices, dehydrated leaves particularly are increasing [13]. Flavoring agents also plays a major role on yoghurt due to the consumer preferences. Vanilla flavor, strawberry flavor, mango flavors are added into the yoghurt as a flavoring agent. Therefore, addition of essential oils extracted from spices, some leaves are added in to the yoghurt as a nano-emulsion and functional ingredients and act as a flavoring agents to develop spicy or leafy flavored herbal yoghurt in to the market and test for its quality properties and microbial level.

Therefore, addition of essential oils extracted from spices, some leaves are added in to the yoghurt as a nano-emulsion and functional ingredients to develop spicy or leafy flavored paneer in to the market and test for the characteristics such as physicochemical, and functional properties, antimicrobial activity and stability are very important to evaluate the possibility of using essential as nano-emulsion in paneer. It will include the food law criteria for applicable country.

Research methods

Fresh milk available at the market was taken in to consideration to have standard level of nutrients and additives [14]. The starter culture commercial brand available at study area contains *Streptococcus thermophiles* and *Lactobacillus delbrueckii ssp. Bulgaricus*was be used [15]. Essential oil emulsion with 300 µLl/kg was added in to the yoghurt with 3 replicates. Whole milk was pre-heated to 45 °C and centrifuged. Standardizing (Pearson Square method) was carried out to maintain minimum of 3.25% milk fat and 8.25% milk SNF [16], and has a titratable acidity of 0.9%, expressed as lactic acid. After that, milk was homogenized at a pressure of 7 MPa and pasteurized at 90 °C for 10 minutes (Batch pasteurization), cooled to incubation temperature. The prepared EOs were added in to the mixture and inoculated with starter culture in a quantity of 2g/100g [14]. The sterilized containers were used to fill the yoghurt and incubated at 42°C for 2.5 hours. Then, prepared yoghurts was cooled down to 5 °C and stored at this temperature for further analysis. Spread plate method for total Coli form count**,** pour plate method for Total plate count were done [17]. 1st, to 40th days were considered at an interval of 10 days for shelf life evaluation. Chemical analysis such as pH (Model 230A+) and titratable acidity [18] was tested for the samples.

A sensory evaluation was carried out to find out the best treatment which has long shelf life out of all fur treatments. Sensory panel consisting 30 untrained panelists texture, smell and overall ac-

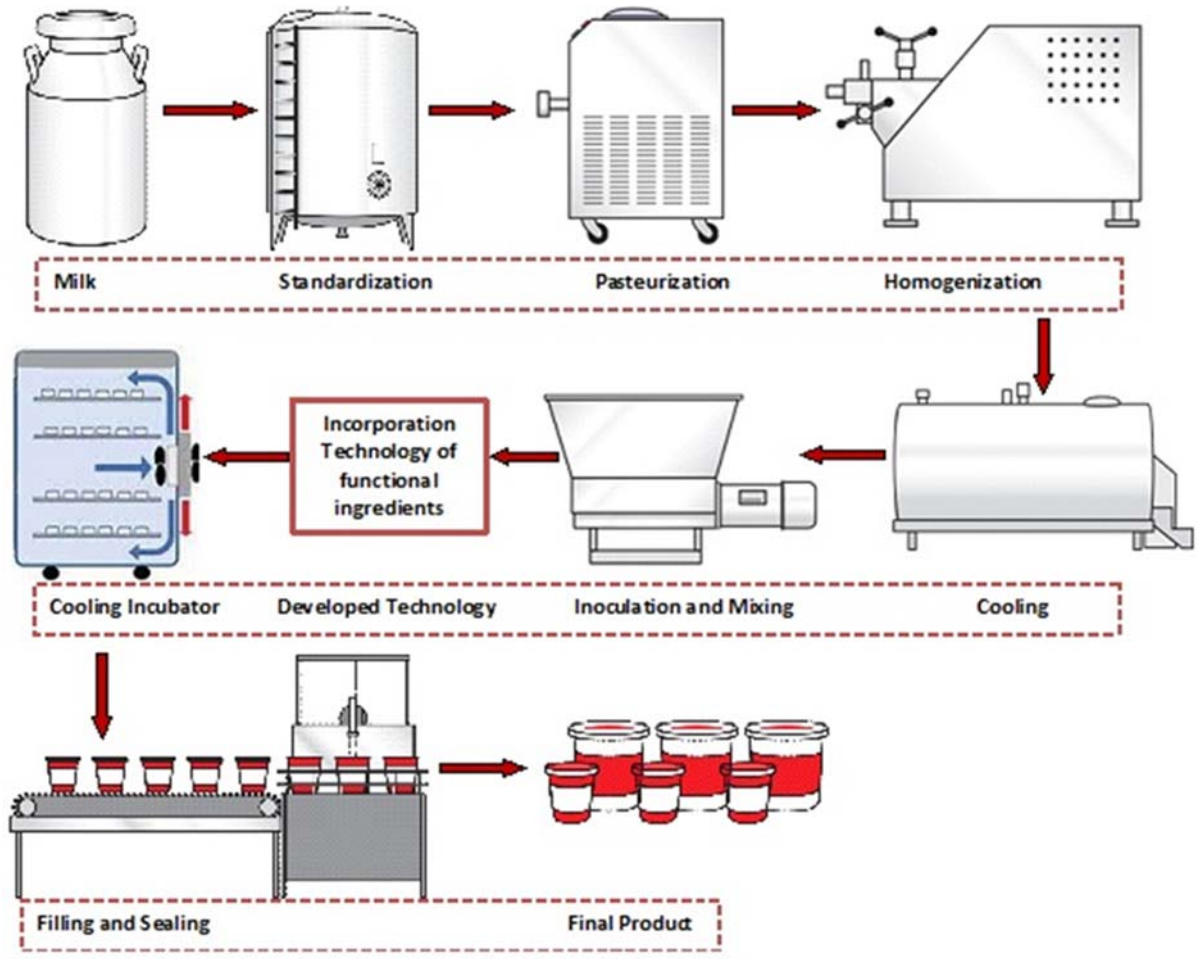

Figure 1. Yoghurt Manufacturing Process

ceptability were evaluated using a 5 points Hedonic scale [19]. Water Holding Capacity of the yoghurt was measured as explained in the previous studies [20, 21]. Non parametric Friedman Test with Statistical software Minitab and tested using Complete Randomized Design in Factorial Experiments in (SAS).

Results and Discussion

Figure 1 describes the whole process of manufacturing yoghurt and the new technology to incorporate EO also stated here for reference. Overall, the addition of EO in oils was done after the inoculation and mixing to eliminate the heat inhibition of functional ingredients in yoghurt.

Streptococcus thermophilus and Lactobacillus bulgaricus (ST and LB) are lactic acid bacteria were used as a starter culture for a satisfactory flavor development in an equal number of both. The stimulating effect on each others' growth is called "Proto-coorperation" is useful for flavour development and for the optimum growth off bacteria. Every sample were not having huge changes in PH value and found that the photo-coporation was not affected and suitable for commercial scale of yoghurt production. [22].

Production of lactic acid is very faster when cultured both rather than individual pure cultures. Also, bacillus spp enhance the growth of the ST by forming small peptides and amino acids mainly valine. Hence, Cocci spps enhance the growth of the bacillus by forming formic acid under anaerobic conditions and by a rapid production of CO_2.When lactic acid production is reached to a certain level it inhibits the growth of the bacteria which is called as "antibiosis". Proto-coorperation and antibiosis are of great importance in the growth yoghurt bacteria as well as for the quality of yoghurt [23].

Chemical analysis of the final products was carried out by the method mentioned in the articles [21]. The chemical composition of the essential oils added yoghurt is shown in Table 01. The pH of all EO added samples were not significantly

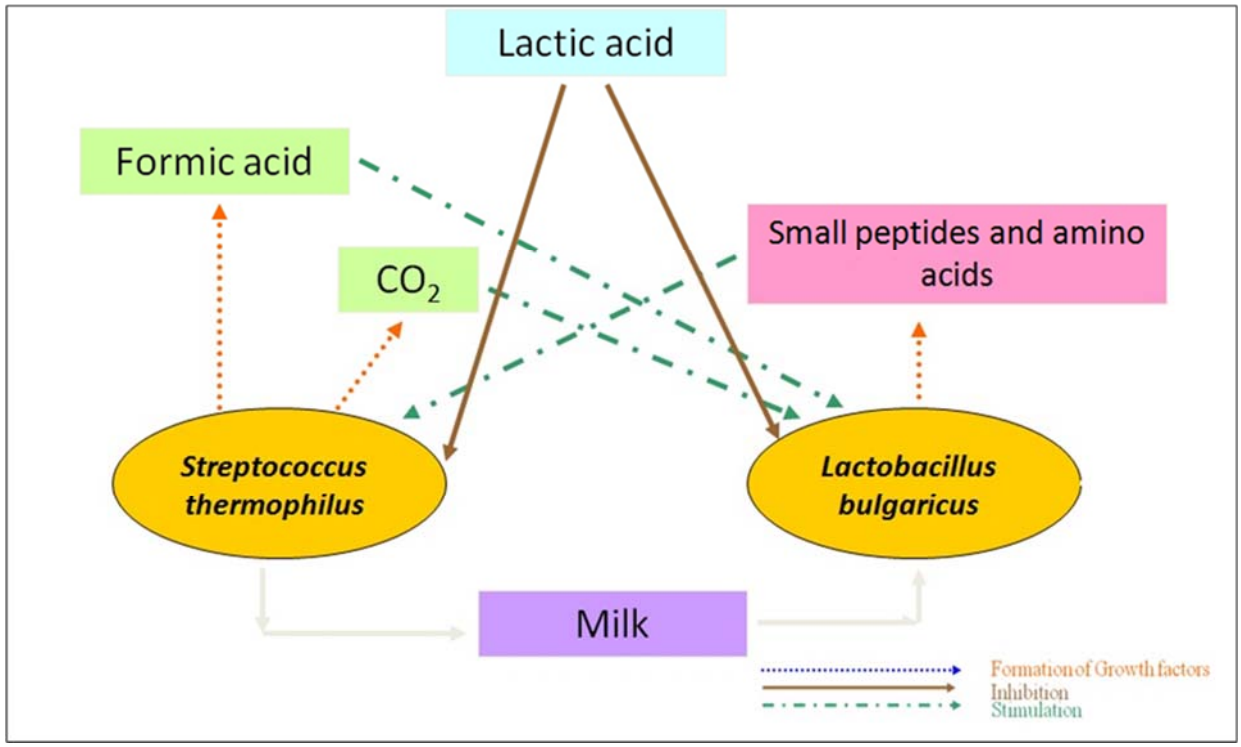

Figure 2. Outline of the stimulation and the inhibition of growth of yoghurt bacteria in milk.

affected (P≥0.05). Therefore, the setting time and other curdling time were not affected. This may be due to the low concentration of EOs used [24]. Also, the moisture, protein, SNF and fat contents were almost same for all samples including control samples. This indicates the there were no significant effect of the EOs on these parameters. Also, there were slight denature of protein, still due to the short processing time but here batch pasteurization was used, Also, vitamins are almost completely preserved. The effect of heat treatment increases the absorption of nutrients by 20-25%, and a number of vitamins, including E, D, B4, in the absence of intense lighting and an oxidizing agents are quite resistant to temperature [25].

One of the researches [26] revealed that the pH of the yoghurt was depending on the milk composition, ingredients and the lactic acid bacteria used to produce yoghurt. Also the EO sources such as fruits or spices affect the degree of acidity and its composition in yoghurt. Garlic EO added yoghurt was having a slight consistency in pH. The need for widely usable and easily available bioactive lipids and natural antioxidants continues to grow [27]. Therefore, it is widely used in yoghurt to improve functionality.

Titratable acidity changes of treated samples are shown in table 2 and showed that it was significantly different from control sample due to the addition of oils. Control sample showed the highest titratable acidity (P≤0.05) while 1st day and 40th days values of titratable acidity were found to be similar. The reason for increase in the titratable acidity was due to lactic acid fermentation [28].

Heat treatment of milk results in destruction of microorganisms, and denatures the whey

Table 1

Nutrition analysis of EO added yoghurt

Treatment	Moisture %	Fat %	SNF %	Protein %	Ash %
Control	82.30±1.09	6.20±0.19	14.30±1.29	4.17±0.15	0.42±0.09
Cinnamon EO	82.20±0.91	6.10±0.19	14.10±0.81	4.18±0.14	0.43±0.08
Garlic EO	83.28±1.08	6.20±0.17	14.48±1.18	4.10±0.17	0.43±0.09
Cumin EO	83.73±1.07	6.10±0.18	14.13±1.17	4.21±0.19	0.45±0.05
Clove EO	83.34±1.10	6.10±0.19	14.24±1.20	4.17±0.19	0.43±0.09

Table 2

pH and titratable acidity of the samples

Tested parameters	Storage time (days)	Treatments				
		Control	Cinnamon EO	Garlic EO	Cumin EO	Clove EO
pH	01	4.57	4.79	4.63	4.69	4.79
	10	4.33	4.63	4.61	4.55	4.57
	20	4.27	4.57	4.56	4.42	4.42
	30	4.19	4.31	4.51	4.39	4.38
	40	4.01	4.12	4.32	4.22	4.21
Titratable Acidity %	01	0.52	0.95	0.96	0.95	0.98
	10	0.82	1.03	0.99	1.04	1.13
	20	1.07	1.16	1.08	1.19	1.19
	30	1.11	1.28	1.12	1.24	1.28
	40	1.42	1.39	1.26	1.34	1.31

proteins and retards colloidal calcium phosphate solubility [29]. The total plate count (TPC) of the sample is shown in the Table 3. The TPC of samples revealed that there were significant differences in the total plat count of treatments compared to control in all four treatments. During the storage TPC was increased but when compare with control total plate count of selected treatment was increased in a decreasing rate. Therefore, EO added samples have some effect on reducing of microorganisms. Essential oils are having many healthful properties such as antioxidant and anti-inflammatory [30, 31]. Escherichia coli O157:H7 is recognized as very important pathogen available [32]. Food-borne pathogens such as E. coli O157:H7 is able to survive in acidic conditions and cause infections [33].

Total Coli forms count and Molds evaluation showed that the Coli forms counts and molds were not present in all experiments till 30th days but there were certain number of mold formed in all samples except garlic essential oil added sample at 40th days. It showed that garlic essential oil has significant inhibitory effect on mold. These microorganisms were not observed in all EO added samples during 30th days of storage. It may be due to the hygienic conditions and the in place cleaning mechanism maintained throughout the processing [34, 10].

The sensory evaluation was conducted to parameter that influence the acceptability EO added yoghurt which includes the odour, texture and overall acceptability of the samples (Table 04). The analysis shows that the odour and overall acceptability of cinnamon EO added sample showed a highest level of score while garlic EO added showed the highest score for texture. The gel was pressed with a spoon so as to assess the hardness and its springiness as mentioned in the research article [8]. However, the textural improvement and overall acceptability were ob-

Table 3

Total plate count and total of samples

Treatment	Total plate count (logCFU/ml)				
	Day 1	Day 10	Day 20	Day 30	Day 40
Control	08	10	09	08	06
Cinnamon EO	08	10	09	08	03
Garlic EO	07	09	09	06	03
Cumin EO	08	12	10	06	03
Clove EO	08	09	06	06	03

Table 4

Sensory evaluation for texture, odour and overall acceptance

Treatments	Odour	Texture	Overall acceptability
Cinnamon EO	3.70±0.71	3.14±0.91	3.26±0.91
Garlic EO	3.09±0.81	3.95±0.83	3.14±0.67
Cumin EO	2.11±0.40	2.09±0.59	2.52±0.67
Clove EO	3.82±0.63	2.31±0.92	2.41±0.78

Table 5

Water holding capacity

Days	Water holding capacity (%)				
	Control	Cinnamon EO	Garlic EO	Cumin EO	Clove EO
01	91.51	91.36	89.13	84.97	84.13
10	76.32	90.91	87.26	82.63	79.24
20	75.12	82.31	84.33	78.99	76.18
30	72.63	75.02	71.37	68.43	71.75
40	71.22	72.23	70.33	66.22	69.34

served in garlic EO added sample in a significant level ($p<0.05$).

Water holding capacity (WHC) of the samples is given in Table 05. It indicates that control sample has the highest WHC (91.51%) followed by Cinnamon EO sample (91.36%). It revealed that control and cinnamon EO samples were not having significant difference (p-0.05) in WHC. That starch use in the control ample is the main reason for this WHC [35]. The inter particle interaction between enlarged starch, casein, whey may be the reason for this effect [36].

Conclusion

The best essential oils to incorporate in yoghurt to inhibit bacterial viable counts and mold counts were found to be garlic EO. Cinnamon EO, clove EO added sampled showed slight inhibition, respectively. The most overall acceptance was observed in cinnamon EO added yoghurt and best organoleptic properties were obtained from clove EO added yoghurt. The addition of cinnamon, garlic, cumin and clove EOs could increase the shelf life, oraganoleptic properties and texture while there were some significant improvement in texture of yogurt.

REFERENCES

1. Sapan Patel. *Evaluating The Effect of Milk Protein Concentrates (MPC) Fortification on Rheological Properties of Nonfat Set Yogurt Using Vane Rheometry*, A Research Paper for Master of Science Degree Food and Nutritional Sciences, The Graduate School University Of Wisconsin-Stout, May, 2011. https://www.semanticscholar.org/paper/Evaluating-the-Effect-of-Milk-Protein-Concentrates-Rheometry-Patel/f020bf8208e8fb06f8cc9491ad7a6d44725c2582
2. Nazik E.M.M. Citrus Essential Oils: Current and Prospective Uses in the Food. *Industry.Recent Patents on Food, Nutrition & Agriculture*, 2015, vol. 7, no. 2, pp. 115-127. DOI: 10.2174/2212798407666150831144239
3. Rifky A.L.M, Shabry M.H.M, A.J.H Mubarak, Development of Black Pepper Incorporated Processed Cheese Spread for the Local Market. *International Journal of Academic and applied research*, 2018, vol. 2, no. 4, pp. 6-10. http://ijeais.org/wp-content/uploads/2018/04/IJAAR180402.pdf
4. Bai M., Huang T., Guo S., Wang Y., Wang J., Kwok L., Dan T., Zhang H., Bilige M. Probiotic Lactobacilluscasei Zhang improved the properties of stirred yogurt. *Food Bioscience*, 2020, vol 37. 100718. DOI: 10.1016/j.fbio.2020.100718
5. Hussein H., Awada S., El-Sayed I., Ibrahim A. Impact of chickpea as prebiotic, antioxidant and thickener agent of stirred bio-yoghurt. *Annals Agric. Sci.*, 2020, vol. 65, pp. 49-58. DOI: 10.1016/j.aoas.2020.03.001
6. Gültekin-Özgüven M., Yücetepe A., Altin G., Gibis M., Weiss J., Özçelik B. Stirred-type yoghurt in corporated with sour cherry extract in chitosan-coated liposomes. *Food Hydrocolloids*, 2020, vol. 101. 105532. DOI: 10.1016/j.foodhyd.2019.105532
7. Wang X., Kristo E., LaPointe G., Adding apple pomaceas a functional ingredient in stirred-type yogurt and yogurt drinks. *Food Hydrocol.*, 2020, vol. 100. 105453. DOI: 10.1016/j.foodhyd.2019.105453
8. Ramadan M.F. Nutritional value, functional properties and nutraceutical applications of black cumin (NigellasativaL.) oil seeds: an overview. *Int. J. Food Sci. Technol*., 2007, vol. 42, pp. 1208-1218. DOI: 10.1111/j.1365-2621.2006.01417.x
9. Cemek M., Büyükokuroglu M.E., Bayıroglu F., KocM., Arora R. *Herbal Radiomodulators: Applications in Medicine, Homeland Defense and Space*. CABI, Wallingford, UK, 2008. 56 p. DOI: 10.1079/9781845933951.0000

10. Rifky A.L.M., Irfeey A.M.M. Influence of Different Fried Spice Mix (Cumin, Mustard and Curry Leaves) Level and Coagulants on Chemical and Sensory Qualities of Hard Paneer. *International Journal of Academic and applied research*, 2019, vol. 3, no. 3, pp. 25-30. http://ijeais.org/wp-content/uploads/2019/03/abs/IJAAR190305.html
11. D'Antuono L.F., Moretti A., Lovato A.F.S. Seed yield, yield components, oil content and essential oil content and composition of Nigella sativa L. and Nigella damascene L. *Ind. Crops Prod*., 2002, vol. 15, pp. 59-69. DOI: 10.1016/s0926-6690(01)00096-6
12. Cheikh-Rouhou S., Besbes S., Hentati B., Blecker C., Deroanne C., Attia H. Nigella sativa L., Chemical composition and physic chemical characterristics of lipid fraction. *Food Chem*., 2007, vol. 101, pp. 673-681. DOI: 10.1016/j.foodchem.2006.02.022
13. Choi H.S., Sawamura M. Composition of the essential oil of Citrus tamurana Hort. ex Tanaka (Hyuganatsu). *J Agric Food Chem*., 2000, vol. 48, no. 10, pp. 4868-4873. DOI: 10.1021/jf000651e
14. Sady M., Domagała J., Grega T., Najgebauer-Lejk D. Quality properties of non-fat yoghurt with addition of whey protein concentrate. *Biotechnology In Animal Husbandry*, 2007, vol. 23, pp. 291-299. DOI: 10.2298/bah0701291s
15. Mckinley M.C. The Nutrition and Health Benefits of Yoghurt. *International Journal of Dairy Technology*, 2005, vol. 58, no. 1, pp. 1-12. DOI: 10.1111/j.1471-0307.2005.00180.x
16. Weerathilake W.A.D.V., Rasika D.M.D., Ruwanmali J.K.U., Munasinghe M.A.D.D. The evolution, processing, varieties and health benefits of yogurt. *International Journal of Scientific and Research Publications*, 2014, vol. 4, no. 4, pp. 1-10. https://www.ijsrp.org/research-paper-0414.php?rp=P282540
17. El-Malt L.M., Abdel Hameed K.G., Mohammed A.S. Microbiological evaluation of yoghurt products in Qena city, Egypt. *Vet. World*, 2013, vol. 6, no. 7, pp. 400-404. DOI: 10.5455/vetworld.2013.400-404
18. Md. Saiful Bari, Shariful Islam, Md. Hasan Mahmud, Mohammad Shaokat Ali, Md. Sahidul Islam Khan. Chemical and microbiological evaluation of yoghurt available in the market of Bangladesh. *Wayamba Journal of Animal Science*, 2015, vol. 1, no. 1, pp. 1119-1123. https://www.cabdirect.org/cabdirect/abstract/20163080735
19. Mubarak A.J.H., Rifky A.L.M., Shabry M.H.M., Ranadheera C.S. Food Preservative Characteristics of Dehydrated Murunga (MoringaOleifera) Leaf Powder. *International Journal of Academic and Applied Research* (IJAAR), 2018, vol. 2, no. 8, pp. 18-26. http://ijeais.org/wp-content/uploads/2018/08/IJAAR180804.pdf
20. Crispin-Isidro G., Lobato-Calleros C., Espinosa-Andrews H., Alvarez-Ramirez J., Vernon-Carter E. J. Effect of inulin and agave fructans addition on the rheological, microstructural and sensory properties of reduced-fat stirred yoghurt. *LWT-Food Science and Technology*, 2015, vol. 62, pp. 438-444. DOI: 10.1016/j.lwt.2014.06.042
21. Heba H. Salama, Hoda S. El-Sayed, Adel M.M. Kholif, Amr E. Edris. Essential oils nanoemulsion for the flavoring of functional stirred yogurt: Manufacturing, physic chemical, microbiological, and sensorial investigation. *Journal of the Saudi Society of Agricultural Sciences*, 2022, vol. 21, pp. 372-382. DOI: 10.1016/j.jssas.2021.10.001
22. Panagiotis Sfakianakis, Constatnina Tzia. Conventional and Innovative Processing of Milk for Yogurt Manufacture; Development of Texture and Flavor: A Review. *Foods*, 2014, vol. 3, no. 1, pp. 176–193. DOI: 10.3390/foods3010176
23. Cogan T.M. Susceptibility of cheese and yoghurt starter bacteria to antibiotics. *Applied Microbiology*, 1972, vol. 23, no. 5, pp. 960-965. DOI: 10.1128/am.23.5.960-965.1972
24. Njoya Moyouwou Amadou, Ejoh Abah Richard, Nain Caroline Waingeh, Imele Hélène, Yakum Kelly Ndombow, Kuiate Jules-Roger. Physicochemical and Sensory Propertiesof Ginger Spiced Yoghurt. *Journal of Nutritional Therapeutics*, 2017, vol. 6, pp. 68-74. DOI: 10.6000/1929-5634.2017.06.03.2
25. Farmonov J., Serkayev Q., Samadiy M. Investigation of the Effect Of Heat Treatment on the Release of Linseed Oil. *European Science Review*, 2021, vol. 2, pp. 26-29. DOI: 10.29013/esr-21-7.8-26-29
26. Ayar A., Gürlin E. Production and sensory, textural, physic chemical properties of flavored spreadable yogurt. *Life Science Journal*, 2014, vol. 11, no. 4, pp. 58-65. http://www.lifesciencesite.com/lsj/life1104/006_21774life110414_58_65.pdf
27. Jasur Farmonov, Murodjon Samadiy, Qamar Serkayev, Toyir Safaroy, Changeng Liu. Research of The Process of Extraction of Black Cumin Oil With Preliminary Heat Treatment, Food Processing. *Chemistry and Chemical Engineering*, 2021, vol. 3, pp.66-69. DOI: 10.51348/nbgt8512
28. Yousef M.., Nateghi L., Azadi E. Effect of different concentration of fruit additives on some physic chemical properties of yoghurt during storage. *Ann. Biol. Res*., 2013, vol. 4, no. 4, pp. 244-249. https://scirp.org/reference/referencespapers.aspx?referenceid=2502544
29. Ghodekar D.R. Factors affecting quality of paneer - A review. *Ind. Dairyman*, 1989, vol. 41, no. 3, pp. 161-164. https://sphinxsai.com/july-sept_2010_vol2.3/pharmtech/pharmtechvol2.3july-sept210/PT=41%20_1916-1923_.pdf
30. Kostadinovic Velickovska S., Bruhl L., Mitrev S., Mirhosseini H., Matthaus B., Quality evaluation of cold-pressed edible oils from Macedonia. *European Journal of Lipid Science and Technology*, 2015. vol. 17, no. 12, pp. 2023-2035. DOI: 10.1002/ejlt.201400623
31. Ahmad A., Mishra R.K., Vyawahare A., Kumar A., Rehman M.U., Qamar W., et al. Thymoquinone (2-isopropyl-5-methyl-1, 4- benzoquinone) as a chemopreventive /anticancer agent: Chemistry and biological effects. *Saudi Pharmaceutical Journal*, 2019, vol. 27, no. 8, pp. 1113-1126. DOI: 10.1016/j.jsps.2019.09.008
32. Padhye N.V., Doyle M. P. Escherichia coli O157:H7: Epidemiology, pathogenesis, and methods for detection in foods. *Journal of Food Protection*, 1992, vol. 55, pp. 555–565. DOI: 10.4315/0362-028x-55.7.555
33. Evrendilek G. Survival of Escherichia coli O157:H7 in yogurt drink, plain yogurt and salted (tuzlu) yogurt: Effects of storage time, temperature, background flora and product characteristics. *International Journal of Dairy Technology*, 2007, vol. 60, no. 2, pp. 118-122. DOI: 10.1111/j.1471-0307.2007.00312.x
34. Assem M., El-Sayed H., Matter M., Hanafy M., Amer A. Effects of carnation essential oil extracted from Carnation Calli on extending shelf life of yoghurt. *Plant Tissue Culture and Biotechnology*, 2019, vol. 29, pp. 1-14. DOI: 10.3329/ptcb.v29i1.41974
35. Lobato-Calleros C., Ramírez-Santiago C., Vernon-Carter J., Alvarez-Ramirez J. Impact of native and chemically modified starches addition as fat replacers in the viscoelasticity of reduced-fat stirred yogurt. *J. Food Eng*., 2014, vol. 131, pp. 110-115. DOI: 10.1016/j.jfoodeng.2014.01.019
36. Genovese D., Rao A. Role of starch granule characteristics (volume fraction, rigidity, and fractal dimension) on Rheology of starch dispersions with and without amylose. *Cereal Chem.*, 2003, vol. 80, pp. 350-355. DOI: 10.1094/cchem.2003.80.3.350